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NATIONAL BUREAU OF STANDARDS REPORT

10 244

Preliminary Report

INTERLABORATORY EVALUATION OF SMOKE DENSITY CHAMBER



U.S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

NATIONAL BUREAU OF STANDARDS

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NBS REPORT

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INTERLABORATORY EVALUATION OF SMOKE DENSITY CHAMBER

by

T. G. Lee

IMPORTANT NOTICE

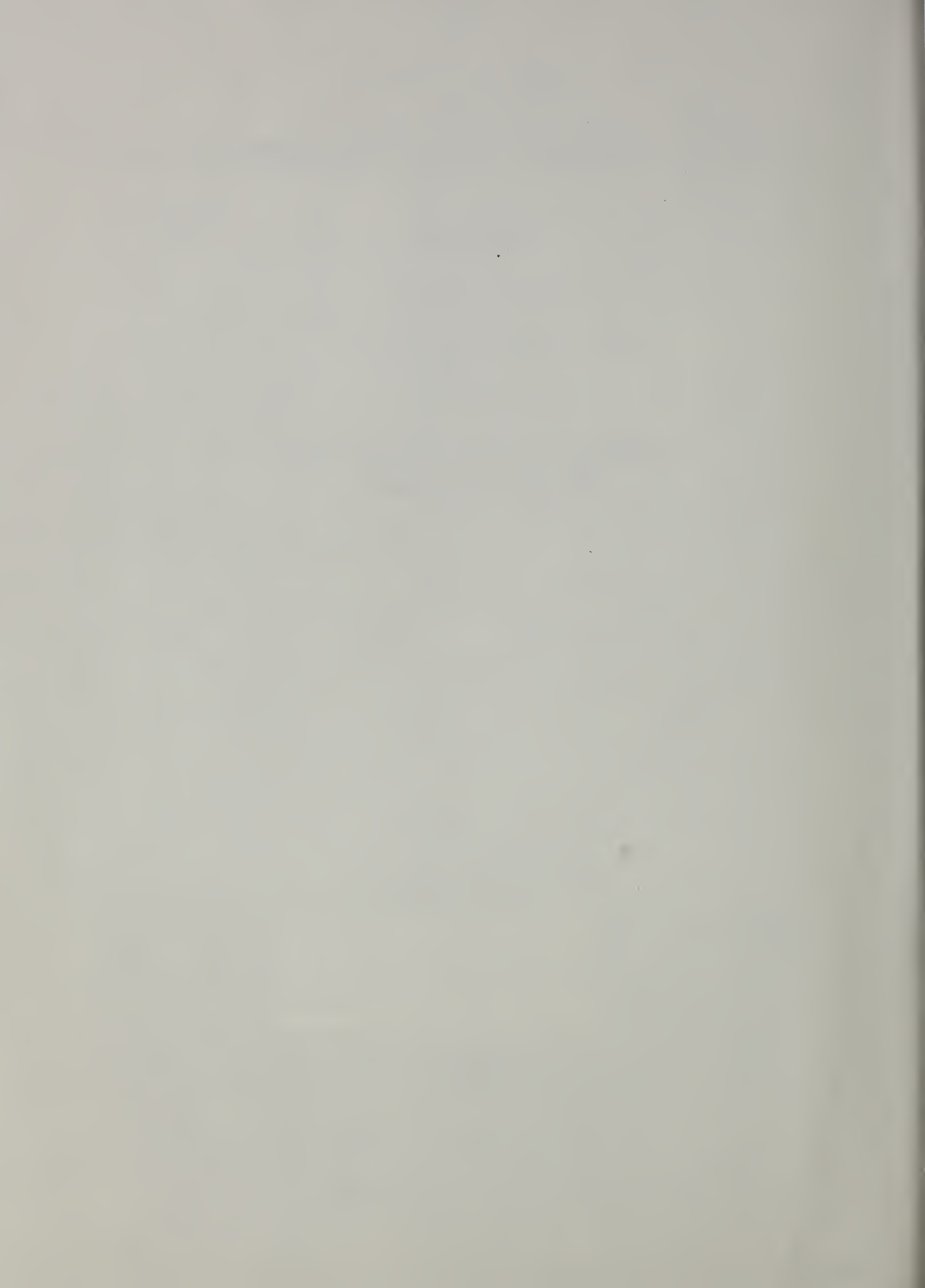
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U.S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS



Preliminary Report
Interlaboratory Evaluation of
Smoke Density Chamber

1.0 INTRODUCTION

In January 1970, an interlaboratory comparison study on the measurement of Smoke Generation Characteristics of Materials was initiated by the Fire Research Section of the National Bureau of Standards (NBS). ASTM Committee E-5 on Fire Tests of Materials and Constructions acted as an advisor to the study. The goal of the study was to evaluate the suitability of the test method for measuring and classifying materials according to their smoke generation potential.

The test method had been developed at NBS and reported in 1967 by Gross, Loftus and Robertson [1]. It was later (1969) used to evaluate the smoke properties of over 140 aircraft interior materials [2]. The laboratory method measures the smoke generation characteristic of materials under two prescribed and standardized conditions, smoldering and flaming, which reflect two parameters of fire hazard. In the test, smoke from a burning specimen in an enclosed chamber is monitored continuously by a photometer which measures the attenuation of light caused by the smoke.

Because of the general interest in the problem of smoke and the need for standardization of equipment, the American Instrument Co. (AMINCO) decided to build a commercial model of the smoke chamber. These production models became available in the latter part of 1969; while many home-built units were made earlier.

In late 1969, NBS circulated a proposed test method to all known users of the Smoke Density Chamber for comments. Many constructive suggestions were received and were incorporated in a revised draft of the test method. All laboratories having a Smoke Density Chamber were then invited to participate in an interlaboratory evaluation of the method and over three-quarter replied favorably. Two samples each of two materials (pure α -cellulose paper and a PVC-PVA copolymer) were distributed for a preliminary screening and general familiarization with the test procedure. The reported results and comments indicated the need to provide better alignment of the burner in the flaming exposure; and to correct the clear beam reading caused by the window deposits. The results of this initial study showed a between-laboratory coefficient of variation of 2.6% for smoldering α -cellulose (mean $D_m = 162$) and 7.1% for flaming

- [1] D. Gross, J.J. Loftus and A.F. Robertson, "Method for Measuring Smoke from Burning Materials", ASTM Special Technical Publication No. 422 (1967)
- [2] D. Gross, et al, Smoke and Gas Produced by Burning Aircraft Interior Materials, Building Science Series 18, U.S. Government Printing Office (1969)

PVC/PVA plastic (mean Dm = 553) for the first 12 reporting laboratories. The reproducibility was considered reasonable for tests of this type.

A meeting, attended by representatives from some of the participating laboratories in the round-robin was held on February 16, 1970 to discuss the preliminary test results and test procedures. A more comprehensive interlaboratory evaluation of the test method followed the preliminary tests. The data on the important single value of smoke potential - maximum specific optical density - is summarized in this report for those laboratories who reported their data before May 20, 1970.

2.0 PARTICIPANTS

A total of 17 laboratories, three with home-built and 14 with AMINCO chambers reported their results. These were:

| <u>Laboratory</u> | <u>Location</u> | <u>Representative</u> |
|--|----------------------|-----------------------------|
| DuPont (Engineering Test Center) | Newark, Del. | F. Thompson |
| DuPont (Plastics Dept.) | Wilmington, Del. | J. Blair |
| Federal Aviation Adm. (NAFEC) | Atlantic City, N.J. | J. F. Marcy E. Nicholas |
| Forest Product Lab (Madison) | Madison, Wisc. | H. W. Eickner J. Brenden |
| General Electric Co. (Plastic Dept) | Mt. Vernon, Ind. | C. Bialous |
| General Tire & Rubber Co. (Chem Plastic Dept) | Akron, Ohio | G. Wear |
| Johns-Manville (Research Center) | Mansville, Ohio | E. Davis |
| Lawrence Radiation Laboratory | Livermore, Calif. | J. Gaskill |
| Mobay Chemical | Pittsburgh, Pa. | R. Hagins |
| National Bureau of Standards | Gaithersburg, Md. | T. Lee |
| National Research Council (Canada) | Ottawa, Canada | J. McGuire |
| Owens Corning Fiberglas Corp. | Granville, Ohio | P. Hays |
| Union Carbide (Plastic Dept.) | S.Charlestown, W.Va. | C. Hilado |
| Uniroyal Inc.(Research Center) | Wayne, N. J. | M. Jacobs |
| Uniroyal Inc. | Mishawaka, Ind. | G. Jablonski |
| Rohm & Haas Co.(Redstone Res. Lab) | Huntsville, Ala. | T. Pratt |

The laboratories are identified in the report by code letters only.

3.0 TEST PROCEDURES

The detailed test procedures were described in a revised test method standard, (see attachment). Supplementary notes, instructions, data sheets, and a total of 26 specimens were distributed to the participants after they reported their preliminary test results.

There were a total of eight materials and 10 test conditions (two materials were tested under both flaming and smoldering conditions). The instructions requested that duplicate tests be preformed for each of the test conditions, and an additional six replicates for one designated test condition. This arrangement was selected to permit good statistical estimates to be made of (within-laboratory) repeatability and (between-laboratory) reproducibility with a reasonable small number of tests.

The experiment design is shown in Table 1. It was suggested that tests be made in random order, but some laboratories tested duplicates in sequence. A few did not condition the specimens prior to tests because of the lack of facility or time.

4.0 TEST MATERIALS

The materials selected (see Table 2) represent common interior finish and construction materials including simple and composite plastic, cellulosic and inorganic-base materials covering a wide range of thickness. These materials exhibit different forms of physical response to fire exposure: such as slow melting, fast shrinking, rapid decomposition and nearly non-reactive. The smoke levels from the materials covered the range of the test instrument as well as a very narrow region to show the degree of resolution. Most materials were obtained from commercial sources without special controls on uniformity.

Since small quantities of fillers, pigments and additives, and other chemical and physical properties, affect the smoke potential of materials it should not be assumed that all materials of the same generic type would produce the same quantity of smoke under the same conditions.

5.0 RESULTS

Table 3 lists for each of the 17 laboratories the duplicate values of $D_m(\text{corr})$, the maximum specific optical density. Table 4 shows the average values of the duplicate determinations of $D_m(\text{corr})$ for each test condition and laboratory.

Table 5 summarizes for each material the arithmetic mean, the standard deviation between laboratories and within laboratories (based on duplicate tests) and the corresponding coefficients of variations. This data is based on results from the 13 laboratories with the AMINCO model. Fig. 2 shows the correlation of each lab against the mean.

Results of one AMINCO (LL) and all three home-built (A, E, C) models are not included in this analysis for statistical reasons.

Table 6 shows the ranking order of the laboratories for each material and the sum of the ranking (score) for each laboratory. A ranking order of 10, for example, means that the particular laboratory has a Dm value higher than nine other laboratories for that material. The score for a laboratory is based on the sum of the rankings for all materials. If the score departs from an expected limits (with 95% confidence level) which can be accounted for by random error, the presence of systematic error is assumed. Lab S exceed the limiting score; (77 for the number of labs and materials involved) and the data is considered suspect [3].

A convenient way of showing systematic deviations is to plot the value for each laboratory against the mean value for all laboratories for the various materials. This is shown in Fig. 1 for the two consistently high and two consistently low laboratories.

Table 7 shows the frequency distribution of each material. The full range of the reported values is divided into 10 equal intervals and the number of laboratories whose values fit within each interval is stated. This distribution shows, for example, that one or two laboratories at the extreme ends can effect the calculated mean and standard deviation.

6.0 DISCUSSION

This round robin was designed to examine statistically the range of validity of the test method by including materials with a wide range of properties in terms of composition, thickness, reaction to heat and flame, and production of smoke. It included diverse types of laboratories - research as well as testing oriented; experienced as well as new to the smoke work. The results, therefore should reflect a conservative estimate of the method's precision.

An interlaboratory test of this type indicates to the participating laboratories who have reported systematic deviations from the average, the need for them to examine their procedures more carefully. One or two values for some materials in Table 4 are very close to the limit for discard under statistical procedures. They, nevertheless, were not excluded though it would improve the result on reproducibility. However, the data from Lab LL for two materials justify rerun because of the high within-lab variability; Lab - LL is not included in this analysis. The optical system and thermal properties of the inside walls varies between the home-built and AMINCO models. The data from the former are being analyzed separately and are not included here.

The results of the Dm(corr) values show that deviations between laboratories (reproducibility) may be three times greater than the deviation within a laboratory (repeatability). This implies that variations in procedures

[3] Youden, W. J., Ranking Laboratories by Round-Robin Test. Material Research Standard. 3 1, 9-13 (1963)

among laboratories account for most of the error rather than specimen variation. The deviation in reproducibility was much less for those laboratories who had attended the pre-test briefings; as compared to those who had not attended.

Looking at Table 5, under the smoldering exposure condition the five non-melting materials have a maximum coefficient of variation of 9.3%. The other two materials which melt, ABS and Polystyrene, have coefficients of variation of 12 and 27% respectively. However, the 27% coefficient of variation represents a standard deviation of only 6.3. The ABS melts gradually and flows down away from the center high irradiance region. The Polystyrene foam melts and shrinks into the bottom of the holder rapidly where the bottom edge shields it from further exposure. These changes in shape and position during exposure introduce somewhat higher variability.

Under the flaming exposure, the large coefficient of variation for tile may have been partially caused by specimen non uniformity (irregular hole size). For both the tile and the PVC faced gypsum, the actual value of the S.D. is only 7.6 and 19 respectively, representing low absolute variations for low smoke producing products.

7.0 CONCLUSION

The results of laboratory variability of $D_m(\text{corr})$, maximum specific optical density, for a wide variety of materials from 13 laboratories using AMINCO model Smoke Density Chambers are presented. The results are reasonable relative to other round robin studies involving flaming or fire tests. A more detailed analysis of the complete results taking into account values other than that for $D_m(\text{corr})$ will be made and sent to the participating laboratories after all the round-robin participants have sent in their data.

8.0 ACKNOWLEDGEMENT

We would like to thank each participating laboratory and their representative for their helpful comments, effort and cooperation in making this joint study possible; the participants for attending the pre-test conference; Forest Products Lab for providing the red oak specimens; and Dr. H.Ku (NBS) for advice on the statistical design and analysis.

TABLE I

Interlaboratory Evaluation of Smoke Density Chamber Test Method
Schedule of Tests

| Specimen | Condi- tion | LABS | | | | | | | | | | | | | | | | | |
|--------------------------------|----------------|------|---|---|---|----|---|---|---|----|---|---|---|---|---|---|---|---|---|
| | | A | | | | EE | | | | LL | | | | | | | | | |
| | | S | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R |
| Linoleum | S | 8 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 8 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Polypropylene Rug | S | 2 | 8 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 8 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Red Oak, 1/4" | S | 2 | 2 | 8 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 8 | 2 | 2 | 2 | 2 | 2 | 2 |
| ABS | S | 2 | 2 | 2 | 8 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 8 | 2 | 2 | 2 | 2 | 2 |
| Polystyrene Foam, 1" | F | 2 | 2 | 2 | 2 | 8 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 8 | 2 | 2 | 2 | 2 |
| | S | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Cellulose Paper | S | 2 | 2 | 2 | 2 | 2 | 8 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 8 | 2 | 2 | 2 |
| PVC - Veneer Gypsum Board | F | 2 | 2 | 2 | 2 | 2 | 2 | 8 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 8 | 2 | 2 |
| | S | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 8 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 8 | 2 |
| Acoustic Tile, Mineral Type | F | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 8 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 8 |

F = Flaming

S = Smoldering

Table 2

Test Materials

(all specimens are 3" x 3")

| Material | Thickness inch | Density lb/ft ³ g/cm ³ | | Color | Description |
|---|-----------------------|---|-------|------------------|---|
| Linoleum | 0.125 | 87 | 1.4 | Green | "battleship" linoleum with burlap backing |
| Polypropylene Rug | 0.22 | 17 | 0.28 | Light Brown | Twist, loop weave, burlap backing |
| Red Oak | 0.25 | 43 | 0.69 | Natural | Uniform grain, wood, smooth finish |
| ABS | 0.022 | 66 | 1.05 | Créam | Flexible plastic opaque |
| α -cellulose | 0.030 | 41 | 0.66 | White | Pure cotton linter matting, (blotter paper) |
| PVC-Gypsum PVC veneer Paper (S) Gypsum | 0.010 0.015 0.5 | 51 | 0.82 | Dark Brown | PVC Veneer, simulating wood grain over gypsum board |
| Acoustic ceiling tile | 0.75 | 20 | 0.32 | Painted White | Mineral type, random and irregular shaped holes |
| Polystyrene Foam | 1.03 | 6.0 | 0.096 | Blue | Rigid low density insulating foam, fire retardant treated |

TABLE 3 Dm(corr.) Values for each Laboratory and Material

| Material / Test Condition | | | | | | | | | | | | | | | | | | | | |
|---------------------------|----------|-----|---------|-----|--------------|--------|---------|------------------|---------|--------------|-----|-----|-----|-----|----|----|-----------------|-----------------|------------------|------------------|
| Non-flaming Exposure | | | | | | | | | | | | | | | | | | | | |
| Lab | Linoleum | Rug | Red Oak | ABS | Poly Styrene | α-cell | PVC-Gyp | Flaming Exposure | | | | | | | | | | | | |
| | | | | | | | | Acous. Tile | PVC-Gyp | Poly Styrene | | | | | | | | | | |
| Run 1 2 | | | | | | | | | | | | | | | | | | | | |
| B | 764 | 733 | 741 | 738 | 562 | 534 | 197 | 205 | 17 | 25 | 164 | 154 | 114 | 109 | 15 | 18 | 57 | 61 | 292 | 254 |
| EE | 795 | 772 | 675 | 652 | 555 | 556 | 195 | 210 | 24 | 32 | 159 | 161 | 113 | 108 | 19 | 20 | 78 | 73 | 326 | 327 |
| F | 792 | 787 | 603 | 623 | 606 | 632 | 204 | 209 | 26 | 20 | 160 | 170 | 107 | 113 | 6 | 7 | 26 | 23 | 413 | 414 |
| G | 687 | 722 | 580 | 580 | 524 | 524 | 147 | 146 | 24 | 19 | 162 | 168 | 113 | 101 | 21 | 18 | 51 | 63 | 327 | 317 |
| H | 632 | 736 | 592 | 588 | 583 | 565 | 153 | 162 | 20 | 25 | 157 | 158 | 104 | 101 | 15 | 19 | 44 | 31 | 408 | 428 |
| I | 695 | 762 | 594 | 601 | 505 | 499 | 193 | 192 | 11 | 11 | 162 | 167 | 108 | 102 | 32 | 34 | 99 | 69 | 459 | 397 |
| K | 704 | 735 | 579 | 593 | 556 | 596 | 166 | 192 | 30 | 27 | 153 | 154 | 102 | 103 | 27 | 27 | 85 | 81 | 320 ⁺ | 359 ⁺ |
| L | 831 | 773 | 656 | 656 | 645 | 600 | 230 | 222 | 24 | 23 | 161 | 154 | 111 | 113 | 16 | 14 | 47 | 50 | 414 | 404 |
| M | 608 | 601 | 583 | 581 | 555 | 545 | 199 | 206 | 29 | 17 | 152 | 155 | 120 | 116 | 29 | 26 | 78 | 80 | 441 | 421 |
| N | 743 | 744 | 498 | 505 | 491 | 499 | 200 | 211 | 18 | 13 | 158 | 167 | 125 | 124 | 17 | 25 | 65 [*] | 55 [*] | 451 | 411 |
| P | 742 | 702 | 628 | 600 | 508 | 479 | 159 | 165 | 23 | 25 | 167 | 159 | 105 | 106 | 21 | 25 | 70 | 71 | 398 | 473 |
| R | 657 | 780 | 596 | 639 | 535 | 555 | 193 | 162 | 33 | 27 | 156 | 162 | 109 | 106 | 11 | 14 | 32 | 30 | 519 | 453 |
| S | 806 | 863 | 682 | 655 | 603 | 567 | 194 | 202 | 24 | 50 | 169 | 166 | 117 | 112 | 6 | 17 | 41 | 69 | 422 | 415 |
| LL | 372 | 568 | 341 | 564 | 520 | 557 | 166 | 198 | 18 | 31 | 184 | 175 | 117 | 113 | 27 | 28 | 89 | 77 | 340 | 132 |
| A | 566 | 532 | 486 | 493 | 473 | 473 | 174 | 195 | 29 | 31 | 158 | 152 | 109 | 120 | 19 | 13 | 108 | 102 | 336 | 374 |
| E | 557 | 564 | 488 | 481 | 492 | 490 | 132 | 130 | 21 | 18 | 144 | 132 | 96 | 88 | 15 | 11 | 31 | 35 | 400 | 400 |
| C | 483 | 508 | 513 | 531 | 352 | 414 | 63 | 110 | 9 | 13 | 142 | 159 | 93 | 91 | 15 | 26 | 24 | 30 | 391 | 452 |
| HOME BUILT | | | | | | | | | | | | | | | | | | | | |

* Assumed values, data not reported

+ Rerun values: 371, 381

• Clear beam value error, assumed 20

TABLE 3 (Cont.) Dm(corr.) Values of 6 Additional Replicates by Each Lab

| Non-flaming | | | | | | | Flaming | | | | | | | |
|-----------------|----------|-----|-----|---------|-----|-----|----------------|---------|------------|---------|---------------|----|----|----|
| Lab | Linoleum | Rug | | Red Oak | | ABS | α -cell | PVC-Gyp | P. Styrene | PVC-Gyp | Acoustic Tile | | | |
| | S | B | K | L | LL | M | F | H | EE | N | P | G | R | I |
| AMINCO MODEL | 842 | 664 | 619 | 608 | 559 | 201 | 164 | 97 | 343 | 343 | 73 | 57 | 13 | 24 |
| | 746 | 689 | 599 | 635 | 534 | 213 | 159 | 102 | 325 | 282 | 66 | 56 | 9 | 20 |
| | 744 | 646 | 597 | 561 | 529 | 215 | 160 | 95 | 345 | 465 | 77 | 54 | 10 | 22 |
| | 789 | 628 | 620 | 591 | 530 | 198 | 171 | 101 | 285 | 478 | 63 | 51 | 9 | 25 |
| | 779 | 628 | 591 | 590 | 518 | 192 | 157 | 100 | 371 | 356 | 67 | 61 | 9 | 30 |
| | 768 | 620 | 630 | 598 | 412 | 176 | 164 | 98 | 287 | 461 | 65 | 53 | 12 | 29 |
| Lab | A | | | C | | | | | E | | | | | |
| HOME BUILT | 530 | | | 338 | | | | | * | | | | | |
| | 513 | | | 374 | | | | | 23 | | | | | |
| | 526 | | | 348 | | | | | 35 | | | | | |
| | 528 | | | 367 | | | | | 32 | | | | | |
| | 520 | | | 373 | | | | | 28 | | | | | |
| | 528 | | | 372 | | | | | 28 | | | | | |
| | | | | | | | | | 31 | | | | | |

* Burner position error, no flaming

Table 4

Dm(corr.) Results (mean of two determinations) for 17 Laboratories

| Lab | Linoleum(S) | Polypropylene(S) | Red Oak (S) | ABS | P.Styrene | α -cellulose | PVC-Gypsum |
|-----|-------------|------------------|-------------|-------|-----------|---------------------|------------|
| B | 743.5 | 759.5 | 540.0 | 201.0 | 21.0 | 159.0 | 111.5 |
| EE | 783.5 | 663.5 | 555.5 | 202.5 | 28.0 | 160.0 | 110.5 |
| F | 789.5 | 613.0 | 619.0 | 206.5 | 23.0 | 165.0 | 110.0 |
| G | 704.5 | 500.0 | 524.0 | 146.5 | 21.5 | 165.0 | 107.0 |
| H | 684.0 | 590.0 | 574.0 | 157.5 | 22.5 | 157.5 | 102.5 |
| I | 723.5 | 597.5 | 502.0 | 192.5 | 11.0 | 164.5 | 105.0 |
| K | 719.5 | 585.0 | 570.0 | 179.0 | 28.5 | 153.5 | 102.5 |
| L | 602.0 | 656.0 | 622.5 | 226.0 | 23.5 | 157.5 | 112.0 |
| M | 604.5 | 582.0 | 550.0 | 202.5 | 23.0 | 153.5 | 118.0 |
| N | 743.5 | 501.5 | 495.0 | 205.5 | 15.5 | 162.5 | 124.5 |
| P | 722.0 | 614.0 | 493.5 | 162.0 | 24.0 | 163.0 | 105.5 |
| R | 713.5 | 617.5 | 545.0 | 177.5 | 30.0 | 159.0 | 107.5 |
| S | 634.5 | 668.5 | 585.0 | 198.0 | 37.0 | 167.5 | 114.5 |
| LL | 470.0 | 452.5 | 538.5 | 182.0 | 24.5 | 179.5 | 115.0 |
| A | 549.0 | 469.5 | 473.0 | 184.5 | 30.0 | 155.0 | 114.5 |
| E | 500.5 | 484.5 | 491.0 | 131.0 | 19.5 | 138.0 | 92.0 |
| C | 495.5 | 522.0 | 383.0 | 86.5 | 11.0 | 150.5 | 92.0 |

Flaming Exposure

| | PVC Gypsum | P. Styrene | Acoustic Tile |
|----|------------|------------|---------------|
| B | 59.0 | 273.0 | 16.5 |
| EE | 75.5 | 326.5 | 19.5 |
| F | 24.5 | 413.5 | 6.5 |
| G | 57.0 | 522.0 | 19.5 |
| H | 37.5 | 419.0 | 17.0 |
| I | 94.0 | 423.0 | 33.0 |
| K | 83.0 | 339.5 | 27.0 |
| L | 48.5 | 409.0 | 15.0 |
| M | 79.0 | 431.0 | 27.5 |
| N | 66.0 | 451.0 | 21.0 |
| P | 70.5 | 435.5 | 23.0 |
| R | 31.0 | 466.0 | 12.5 |
| S | 85.0 | 418.5 | 11.5 |
| LL | 63.0 | 255.0 | 27.5 |
| A | 195.0 | 355.0 | 16.0 |
| E | 33.0 | 400.0 | 13.0 |
| C | 27.0 | 421.5 | 20.5 |

TABLE 5 Results of Dm(corr.) for 13 Lab (AMINCO)

Standard Deviation and Coefficient of Variation

Mean Values, Between-Lab and Within-Lab

| | Non-flaming Exposure | | | | | | Flaming Exposure | | |
|--------------------|----------------------|-----|---------|-----|----------------|---------|------------------|---------|------|
| | Lino | Rug | Red Oak | ABS | α -cell | PVC-Gyp | P. Sty | PVC-Gyp | Tile |
| <u>BETWEEN-LAB</u> | | | | | | | | | |
| Mean | 737 | 616 | 553 | 189 | 160 | 110 | 24 | 58 | 19 |
| S. D. | 58 | 57 | 42 | 23 | 4.4 | 6.3 | 6.4 | 19 | 7.6 |
| Coef.Var % | 7.9 | 9.3 | 7.7 | 12 | 2.8 | 5.7 | 27 | 33* | 37** |
| <u>WITHIN-LAB</u> | | | | | | | | | |
| S. D. | 40 | 13 | 18 | 9.5 | 4.3 | 3.6 | 6.5 | 9.2 | 3.2 |
| Coef.Var % | 5.4 | 2.1 | 3.2 | 5.0 | 2.7 | 3.3 | 27 | 16 | 17 |

* If one outlying value (24.5) is set aside, coef. of var. becomes 28

** If one outlying value (6.5) is set aside, coef. of var. becomes 32

| LAB. | Non-Flaming Exposure | | | | | | Flaming | | Non-Flaming Score | Flaming Score |
|------|----------------------|-----|---------|-----|------|-----|---------|------|-------------------|---------------|
| | Lino | Rug | Red Oak | ABS | Cell | PVC | P.Sty | PVC | | |
| B | 9 | 13 | 6 | 8 | 5.5 | 9 | 3 | 7 | 53.5 | 13 |
| EE | 10 | 11 | 8 | 9.5 | 7 | 8 | 10 | 10 | 63.5 | 20.5 |
| F | 11 | 7 | 12 | 12 | 11.5 | 7 | 6.5 | 1 | 67 | 8 |
| G | 3 | 2 | 4 | 1 | 11.5 | 5 | 4 | 6 | 30.5 | 15.5 |
| H | 2 | 5 | 9 | 2 | 3.5 | 1.5 | 5 | 3 | 28 | 16 |
| I | 7 | 6 | 3 | 6 | 10 | 3 | 1 | 13 | 36 | 35 |
| K | 5 | 4 | 10 | 5 | 1.5 | 1.5 | 11 | 12 | 38 | 27 |
| L | 12 | 10 | 13 | 13 | 3.5 | 10 | 8 | 4 | 69.5 | 13 |
| M | 1 | 3 | 7 | 9.5 | 1.5 | 12 | 6.5 | 10.5 | 40.5 | 13.5 |
| N | 8 | 1 | 2 | 11 | 8 | 13 | 2 | 10.5 | 45 | 27.5 |
| P | 6 | 8 | 1 | 3 | 9 | 4 | 9 | 9 | 40 | 31 |
| R | 4 | 9 | 5 | 4 | 5.5 | 6 | 12 | 2 | 45.5 | 18 |
| S | 13 | 12 | 11 | 7 | 13 | 11 | 13 | 5 | 80 | 15 |

Table 7

Frequency Distribution $\eta = 13$

| | | | | | | | | | | | |
|---------------------|---|---|---|---|---|---|---|---|---|---|---|
| Linoleum | 1 | 0 | 0 | 0 | 1 | 2 | 3 | 2 | 1 | 2 | 1 |
| Rug | 1 | 0 | 0 | 0 | 4 | 4 | 0 | 2 | 1 | 0 | 1 |
| Red Oak | 3 | 0 | 0 | 1 | 1 | 3 | 0 | 2 | 1 | 0 | 2 |
| ABS | 1 | 2 | 2 | 0 | 1 | 1 | 1 | 2 | 4 | 0 | 2 |
| α -cellulose | 2 | 0 | 0 | 2 | 2 | 1 | 0 | 2 | 1 | 2 | 1 |
| PVC-Gypsum | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 0 | 1 | 0 | 1 |
| P. Styrene | 1 | 1 | 1 | 0 | 1 | 5 | 1 | 2 | 1 | 0 | 1 |
| P. Styrene/F | 1 | 0 | 0 | 2 | 1 | 0 | 0 | 4 | 4 | 0 | 1 |
| PVC / F | 1 | 1 | 1 | 1 | 0 | 1 | 4 | 0 | 1 | 1 | 1 |
| Tile / F | 1 | 1 | 1 | 1 | 3 | 2 | 1 | 1 | 2 | 0 | 1 |



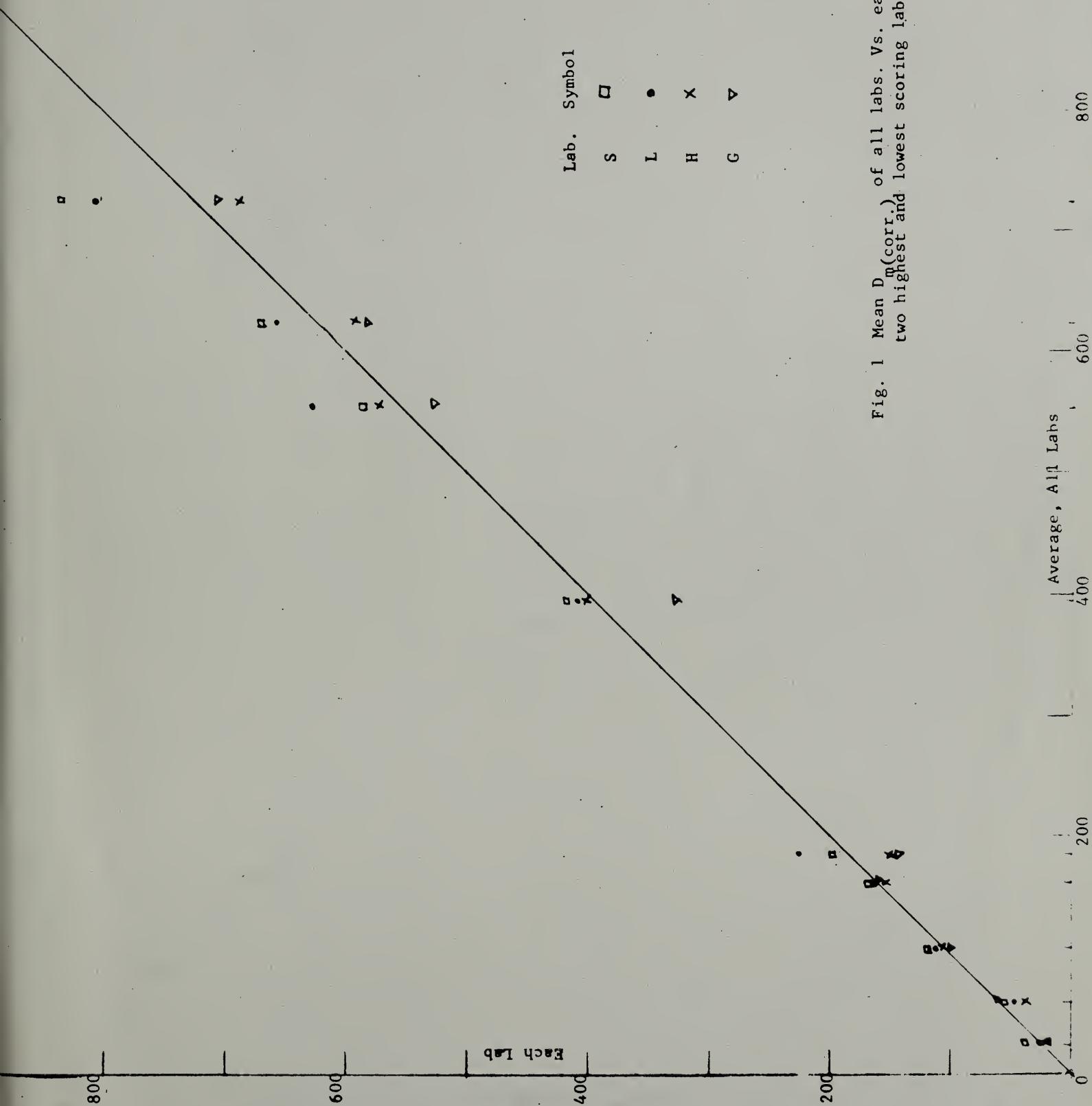


Fig. 1 Mean $D_{m(corr.)}$ of all labs. Vs. each lab. for two highest and lowest scoring labs

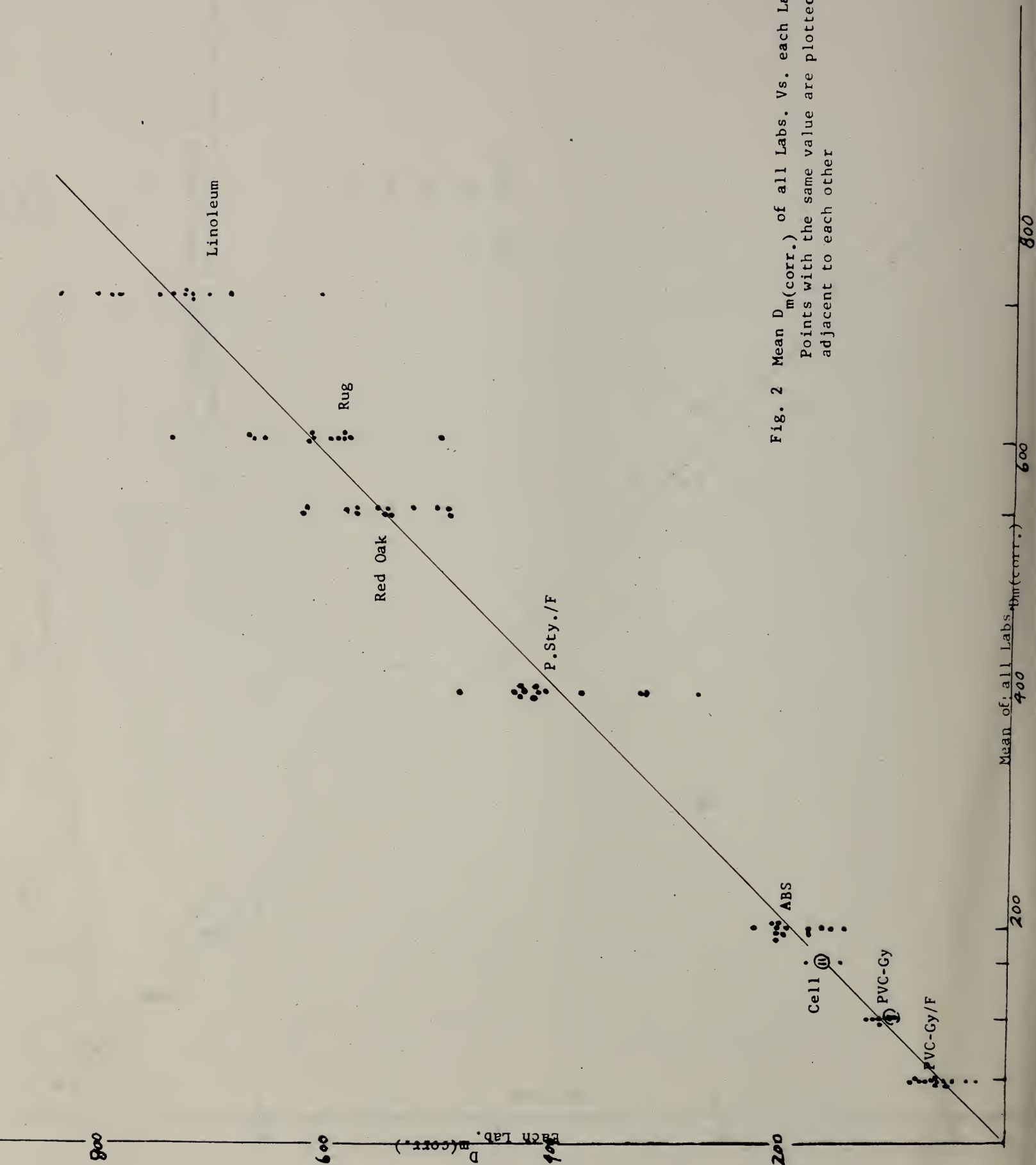


Fig. 2 Mean $D_m(\text{corr.})$ of all Labs. Vs. each Lab.
Points with the same value are plotted
adjacent to each other

